IJARSCT

ISSN (Online) 2581-9429

International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)

IJARSCT
Impact Factor: 6.252

Volume 2, Issue 2, July 2022

Performance Analysis of Grid Connected Induction Generator under Unstable Condition

Sumit Kumar[1] and Rohit Kumar Gupta[2]
M.Tech Scholar, Department of Electrical Engineering[1]
Assistant Professor, Department of Electrical Engineering[2]
School of Engineering & Technology, Soldha, Bahadurgarh, Haryana, India

Abstract: *Over the past few decades, there has been an increasing use of induction generator particularly in wind power applications. In generator operation, a prime mover (turbine, engine) drives the rotor above the synchronous speed. Stator flux still induces currents in the rotor, but since the opposing rotor flux is now cutting the stator coils, active current is produced in stator coils, and motor now operates as a generator, and sends power back to the electrical grid. Based on the source of reactive power induction generators can be classified into two types namely standalone generator and Grid connected induction generator. In case of standalone IGs the magnetizing flux is established by a capacitor bank connected to the machine and in case of grid connection it draws magnetizing current from the grid. This thesis explicitly deals with the study of grid connected induction generators where frequency and voltage of the machine will be dictated by the electric grid. Among these types of IGs, Doubly Fed Induction Generator (DFIG) wind turbines are nowadays increasingly used in large wind farms because of their ability to supply power at constant voltage and frequency. Modern problems with the stability due to increased risk of unstable condition of renewable sources (magnitude and phase) are studied and some of proposed systems are simulated in MATLAB- SIMULINK environment.*

Keywords: Doubly Fed Induction Generator**,** renewable sources**,** Grid connected induction generator

I. INTRODUCTION

Three phase SEIG driven by a variable-speed prime mover as exciter such as a wind turbine used for the clean and clear alternative renewable energy production. Self- excitation process in induction machines makes the machine perfect for applications in isolated power systems. Various models have been ready to develope for steady state operation and unbalanced analysis of self-excited induction generator. The d-q reference framing model, impedance model, admittance based model, output power equations based models, and operational circuit based model are frequently used for analysis of SEIG[1]. Different variables such as variation in excitation of wind speed and load have been taken into account and accordingly the effect on generated current and voltage has been analyzed. The effect of excitation capacitance on generated voltage has been analyzed. The dynamic d- q model derived in this thesis is based on some assumptions: as constant air gap, three phase symmetrical rotor and stator windings, sinusoidal distribution of the air gap magnetic field i.e., space harmonics are neglected. Rotor parameters and variables are referred to the stator winding and core losses are neglected[2]. In this thesis development a dynamic model of SEIG, simulation and analyzation of the transient response of self-excited induction generator. Also transients of generator self-excitation under 3 phase loading conditions are simulated for constant, step change in wind speed using a MATLAB diagram. Also a simulation model on open loop control of GEIG. Due to environmental affected issues caused by excessive exploitation of conventional resources, now the interest is diverted to nonrenewable resources especially solar & wind as these are environmentally clean and eco-friendly. With the modern technology by increasing the efficiency or the output the generation limit of wind has been improved in the grid. So the wind energy generation system requires a technological advancement as well as complex or a reliable connection in the system[3]. This literature survey of used topologies of wind turbines and methodology of control techniques adopted in power system to wind turbine systems mainly induction generator in turbine and the configurations used in the converter for extraction of power from wind. In the paper, the characteristics of FSWT, VSWT drawbacks and comparison are elaborated and we found that VSWT improves with the drawbacks of previous system and also has different advantages like improvement in dynamic performance. The increasing use of renewable energy sources such as bio gas energy, wind energy, solar energy and hydro potential have become to adopt low cost generating system, which are capable to perform operation in the remote areas, and in conjugation with the variety of prime movers. VSWT is described by its working modes and its connection configuration with their relevant characteristics and also the technique of the model of power converter. After all this what the effect of performance of control techniques used on wind turbine is studied and it is followed by the comparison of control schemes. SFO and SVO are used as the main configuration for control mechanism. The performance of the configurations used is checked and how competable are these is with back to back converters also considered[4]. With wind turbine some alternative sources are also used. In this the micro or mini hydro power plants are used. The induction generator have advantage over synchronous generator so it is used as the generating machine. The induction generator have the advantages like ruggedness, brushless, less required maintenance, less price, simplicity, absence of separate excitation source, stability, variability and many more. Self-excited induction generators with the excitation of capacitor is used in isolated system[5].

II. System Description

2.1 GCIG System Configuration

The GCIG system is made of prime mover, induction machine, load and capacitor bank for grid excitation. The formal layout of the GCIG system is shown in Figure 1.

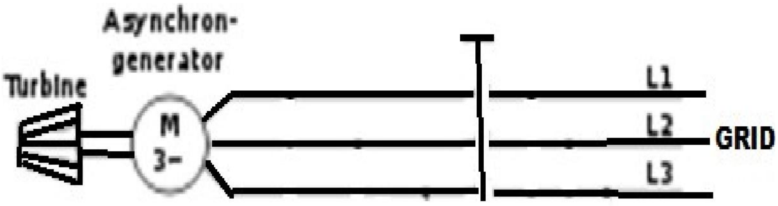


Figure 1 Schematic diagram of a grid-excited induction generator.

The turbine feeds the output power to the induction generator which is required by the load. When the speed of the turbines is not regulated, both the speed and shaft torque vary with variation in the power demanded by the load. The required reactive power to feed generator and threshold need is produced by self-excitation capacitor connected at the stator side of the induction machine. The size of the capacitor is much concerned as it should fulfill the requirement of the reactive power. The low running cost as well as initial cost of a squirrel cage induction generator (SCIG) is less so it is preferred over synchronous generator. The more advantageous figure as no excitation current requirement and no need of direct current excitation source, cage rotor brushless construction and less maintenance requirements [10]. A w e l l suitable capacitor bank is connected at the generator side terminal as variable lagging VAr source. And the requirement of the excitations demand of the cage rotor machine and the load system. The machine used in this is known as a *Self-excited Induction Generator* (SEIG). However, the main drawback of the stand alone SEIG is its poor voltage and frequency regulations under variable loads.

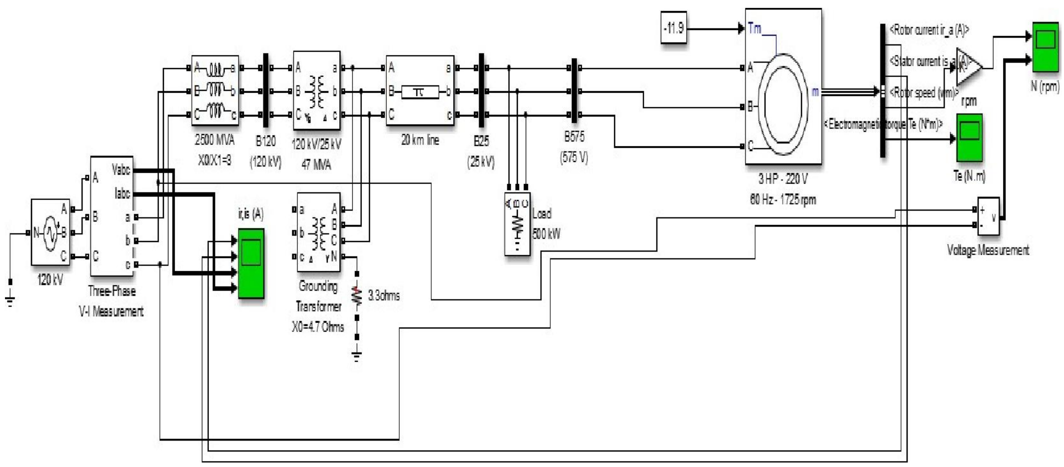


Figure 2 Simulation model of grid-excited induction generator

A change in the load impedance directly affect the excitation of the machine because the reactive power of the excitation capacitor is shared by both the machine and the load. Therefore, the generating voltage drop when the impedance of the load is increased resulting in poor voltage regulations. Poor frequency regulation occurs in an increase in the slip of the induction machine when the load is increased.

The grid-excitation(GE) technique used in induction machine is not so widely used because of its under development . The residual magnetism present in the rotor of the machine produces emf in the stator side at a frequency which is proportional to the rotor speed due to the prime mover driven machine in the station . The reactive current in stator side is caused by the emf applied to the capacitor connected to the stator side. The magnetizing flux produced in machine produces saturation after a time this limits the final value of stator voltage. The induction machine is so can not be used as generator without a grid supply in an isolated location. As the output obtained can be summarized by the loading conditions as well as the characteristics of the machine output quantity. The non linearity in the machine output effects the performance of the machine. The machine parameter as the self- excitation capacitance, speed also effect the output. The change in the load and speed change the demand of lagging var.

2.2 GCIG System Performance

The performance characteristics of the GCIG system depend mainly on the following factors:

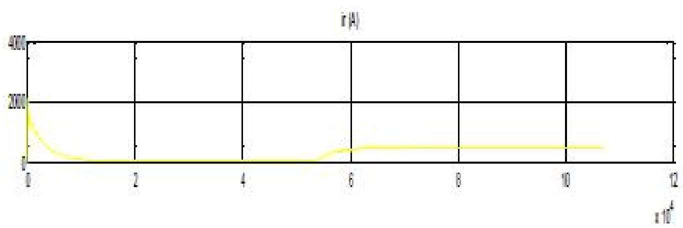
1. The parameter of the induction machine.
2. The machine operating voltage, power factor, rated power, rotor speed and operating temperatures and the induction machine parameter directly affect the performance of the GCIG system.
3. The Self-excitation processed by motor. The connections of a capacitor bank across the induction machines stator terminal is necessary in the case of stand alone operation of the system. The capacitor connections scheme (delta or star) and the use of fixed or controlled grid excitation capacitor have a direct impact on the performance of a GCIG systems.
4. Load parameter.
5. The power factor, start in and maximum torque and current, generated harmonic and load type also affect the performance of the GCIG systems directly.
6. Type of prime movers whether the primary sources is hydro, wind, biomass or combinations of the performance of the GCIG system is affected.

2.3 Operational Problems of the GCIG System

The variation in the load condition are the main operational problem of the GCIG system and the poor frequency and voltage regulation under varying load condition also badly effects the performance. The machine excitation can be affected by change in the load impedance directly. These variations in any quantity like impedance, frequency badly affects the performance of machine so these are among those conditions which are undesirable and more prone to happen in renewable sources. This is because of the reactive power of the excitation capacitor is shared by both the induction machines and the load impedances. Therefore, the generator voltage drops when the load impedance is increased which cause in poor voltage regulation. And slip of induction generator also increases with the increment in load and it will goes increasing till the load increments it completely depends on load and there will be no effect of speed variation.

III. RESULTS AND DISCUSSION

3.1 Current Components and Time Characteristics



DOI: 10.48175/568

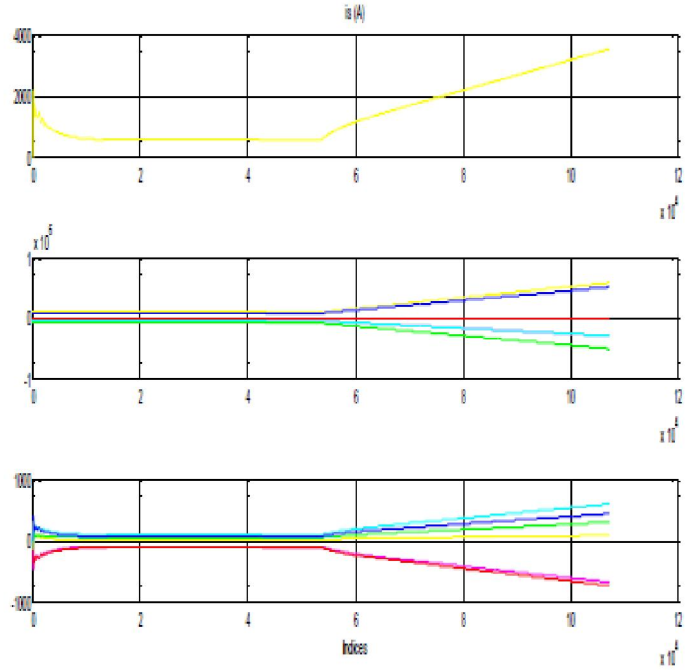


Fig. 3 Current component and time characteristics

3.2 Speed-torque Characteristics

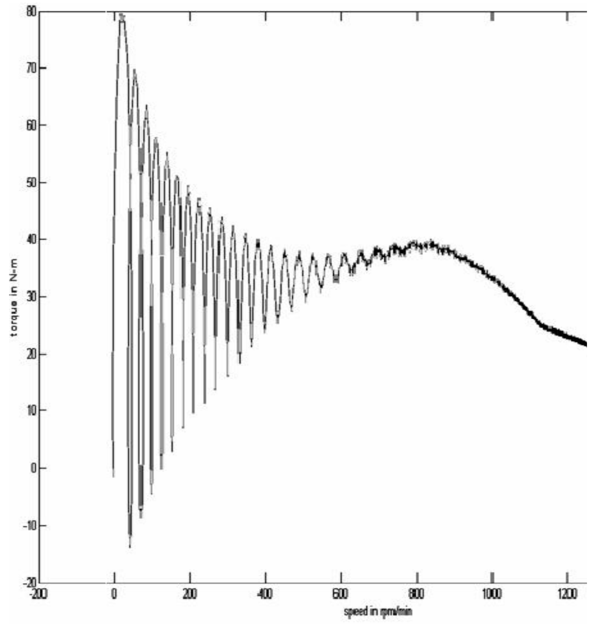


Fig. 4 speed- torque characteristics

IV. DISCUSSION

The torque vs speed characteristics during free movement are as shown in fig. 3 at the starting of induction generator transients occur and this period of operation is called as unstable region of operation due to inverting rotor voltages. After some time torque increase and a steady state is reached. By free movement of generator and rotating it in synchronism the speed with the applied electrical voltage is shown in fig. 4 here the zero position of the reference is selected so that is the amplitude. The transient torque and speed characteristic with time are different from the steady state torques and speed characteristics with time in several respect. As the stator voltage has 50Hz about an average positive value the obtained electromagnetics torque also follows this. The transient value in stator current decays the 50Hz value in torque. In spite of this the dependence of current at the time of application on source voltage, due to the symmetrical machine the dependency on balanced source voltage of the instantaneous torque is zero. We also note from the current plots shown in fig. 3 and fig. 4 that the behavior of the machine currents varies during transient periods. It is shown in a subsequent that this is due to the interaction of the stator and rotor electric transient current.

4.1 Electromagnetic Torque – Time Characteristics

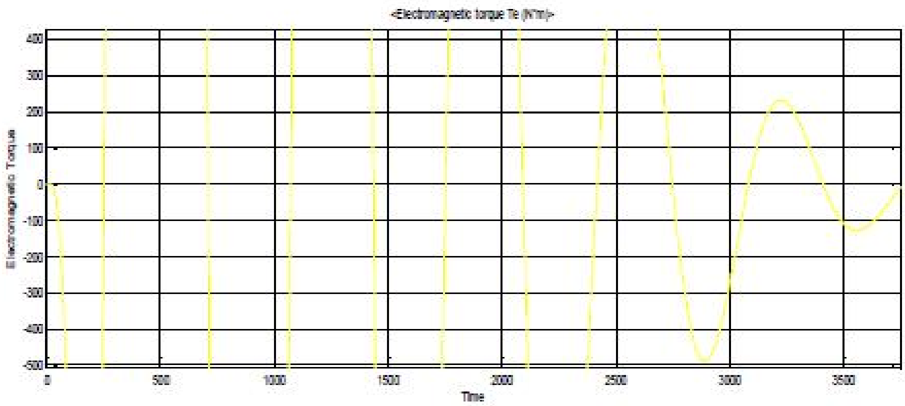


Fig. 5 Torque – Time Characteristics

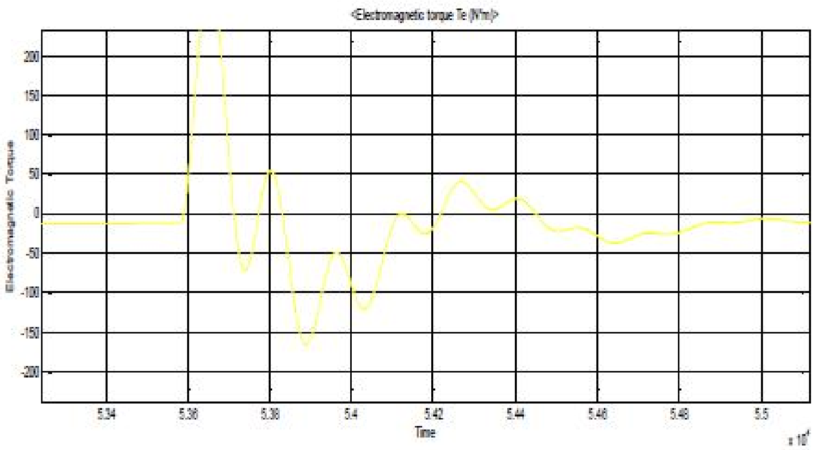


Fig. 6 Torque – Time Characteristics

The dynamic behaviour of the induction generator is shown respectively in figure during unbalanced conditions at grid. At starting generator is operated on the rated parameters to operate the system satisfactorily. The unbalancing at the terminal is simulated by putting the value to zero after passing the value towards one. After few cycles the source voltage re applied. The voltage now decreases to minimum zero level is shown in fig. 6.1.1 during fault occurance in the system both rotor as well as stator current decays as shown in fig. 6.1.2, fig.6.1.3. the transient in this show the behavior of decaying of near 50hz shown fig 6.1.3 these behavior now superimposed with the transient of rotor side so the transient in rotor current affects the decaying in the rotor speed. In case of these machine, both stator and rotor current are highly decaying in nature and the voltage reapplied.

V. CONCLUSION AND FUTURE SCOPE

This thesis present a study of the dynamic performance of variable speed GCIG coupled with either wind turbine or a dc motor and the power systems is subjected to unbalance conditions; as voltage dip, short circuit fault or unbalanced operation. The dynamic behavior of GCIG over power system unbalancing was simulated using MATLAB platform using matrix/vector space control concept. A well conceptual result is needed to observe the result of wind energy on electrical stability system. The GCIG consist in this a slip ring wound rotor induction generator. The stator is connected to grid and the rotor is asserted via a back to back partial scale power converter. Power converters are usually utilizing controlled vector control technique which allow the decoupled control of both active power and reactive power flow to the grid. In the present time investigations, the dynamic IG performance is presented for both normal and abnormal grid condition. The control result of IG is satisfactory in normal grid condition and it is found that, both active power and reactive power attains a study pattern in spite of unbalance wind speed and electrical power supplied to grid is stablized constant. During grid disturbances, on account of considerable torque pulsation of IG and torque oscillation in drive train system has been observed. The detailed result of steady state as well as unbalance grid or faulty condition has been noted and analyzed in chapter 6 with proper justification. In view of that, future scope aims to

- To develop a controller, to improve the stability response of a converter, transient response of the system during faulty grid conditions.
- To develop a simulation base protection system for power electronics converter and induction generator for large disturbances like 3-phase fault of transient duration as the power converter is very sensitive to grid disturbance.

REFERENCES

[1]. Ted K. A. Brekken, Ned Mohan "Under Unbalanced Grid Voltage Conditions Control of a Doubly Fed Induction Wind Generator" vol.no22. 1, march 2007 page129-135.

[2]. T. Ghennam, A. Beugnie "Supervision of reactive power generation for a wind farm" Power Electronics & Application conference on 2-5 sep 2007. On page(s): 1-10 ISBN:978-9276815-10-8

[3]. PaboloSanchis, Jesus Lopez "Control of DFIG under unsymmetrical Voltage sags" IEEE july 2008. Page(s)2466-2462.

[4]. Enrique Escobarb, Roberto Cardenasb, Jon Clarec, Pat Wheeleerc "Control strategy for a DFIG feeding an unbalanced grid or stand-alone load" Electric Power Systems (2009) 3545-364.vol.79

[5]. Johan Morren, W.,Grant, "Ride through of Wind Turbine with Doubly-Fed Induction Generator During a Voltage Sag" IEEE transaction of energy conversion june, 2005 pages 435-4641vol.20

[6]. Sae-Kok, Haan D.M. "Unsymmetrical Fault Diagnosis for a Doubly-Fed Induction Generator" Power Electronics and Drive System, IEEE2007. PEDS '06. 7th International Conference on 26-30 Nov. 2007 Page(s):132 –138

[7]. F. Massaro, L. Dusonchet and E. Telaretti "Unstable Transient stability simulation model of a fixed speed wind turbine system byMatlab/Simulink"

[8]. Marco Landi, "Measurement Techniques for Online Battery State Of Health Estimation in Vehicle to Grid Applications", IEEE Transactions on Instrumentation and Measurement, Vol. 63, No. 5, May 2014.

[9]. Shuang Gao, K. T. Chau, Chunhua Liu, "Integrated Energy Management of Plug in Electric Vehicles in Power Grid with Renewables", IEEE Transactions on Vehicular Technology, Vol. 63, No. 7, September 2014.

[10]. Arman Alahyari, Mahmud Fotuhi-Firuzabad, "Incorporating Customer Reliability Cost in Pev Charge Scheduling Schemes Considering Vehicle To Home Capability", IEEE Transactions on Vehicular Technology, Vol. 64, No. 7, July 2015.

[11]. Adrian Florescu, AntonetaIuliana Bratcu, "Lqg Optimal Control Applied to on Board Energy Management System of All Electric Vehicles",IEEE Transactions on Control Systems Technology, Vol. 23, No. 4, July 2015.

[12]. Corey D. White, K. Max Zhang, "Using Vehicle to Grid Technology For Frequency Regulation and Peak Load Reduction",Journal of Power Sources 196 (2011) 3972–3980

[13]. Albert G. Boulanger, Andrew C. Chu, Suzanne Maxx, and David L. Waltz, "Vehicle Electrification: Status And Issues", Proceedings of The IEEE , Vol. 99, No. 6, June 2011

[14]. Kristien Clement-Nyns, Edwin Haesen, "The Impact of Charging Plug-In Hybrid Electric Vehicles on a Residential Distribution Grid", IEEE Transactions on Power Systems, Vol. 25, No. 1, February 2010.

[15]. Ahmed Yousuf Saber, "One Million Plug-In Electric Vehicles on the Road By 2015",Proceedings of The

12th International IEEE Conference on Intelligent Transportation Systems, St. Louis, Mo, Usa, October 3-7, 2009.

[16]. Santosh kumar, “Modeling and Architectural Frame Work of Off-Board V2g Integrator for Smart Grid”,International Journal of Renewable Energy Research, Vol.4, No.4, 2014.